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AN EVALUATION OF EQUIPMENT-INDEPENDENT MAINTENANCE
TRAINING BY MEANS OF A. (U) BATTELLE COLUMBUS LABS OH
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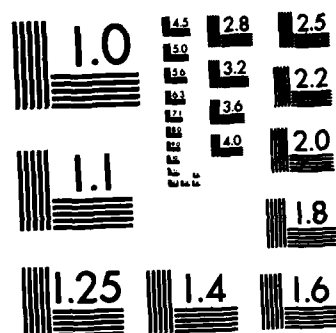
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AN EVALUATION OF
EQUIPMENT-INDEPENDENT MAINTENANCE TRAINING

BY MEANS OF A
MICROPROCESSOR-CONTROLLED VIDEODISC DELIVERY SYSTEM

FINAL REPORT

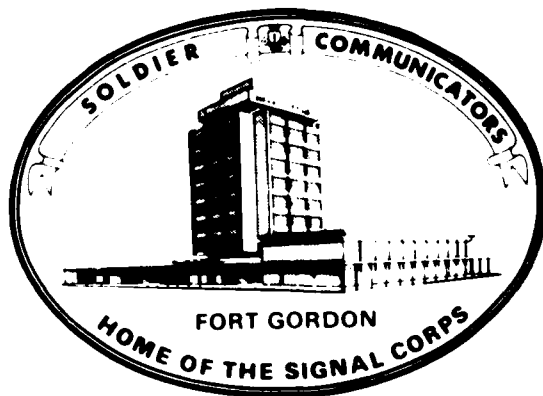
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1 MARCH 1983

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This is the final report on a project to operationally test and evaluate a microprocessor-controlled videodisc (MP/VD) delivery system as a means of providing Equipment-Independent Maintenance Training Programs (EIMTP) in situations where low equipment density limits hands-on training and/or high equipment cost make hands-on equipment training potentially uneconomical. Basic results of the test and evaluation indicate that:		

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#20 Abstract Con't:

a. EIMTP by means of MP/VD delivery systems is an efficient alternative to the current equipment-dependent system of providing such training.

b. EIMTP by means of MP/VD delivery systems is more efficient in terms of the amount of practice time required than the current equipment-dependent system.

c. EIMTP by means of MP/VD delivery systems is less expensive than the equipment-dependent system and therefore is a more cost-effective alternative.

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EXECUTIVE SUMMARY

This project was implemented by the Training Developments Institute (TDI), in response to the request of the United States Army Signal Center and Fort Gordon (USASC&FG), in order to test and evaluate a microprocessor-controlled videodisc (MP/VD) delivery system as a means of providing Equipment-Independent Maintenance Training Programs (EIMTP) in situations where low equipment density and/or high equipment cost make "hands on" equipment training potentially uneconomical. The specific objectives of the test and evaluation were to (1) determine the feasibility of using an MP/VD delivery system to provide effective EIMTP and (2) determine the relative cost and effectiveness of such an EIMTP system in comparison to the current equipment-dependent system.

The unit of instruction selected for the test was a three day laboratory, dealing with the programming of the AN/GSC-24 multiplexer, within the MOS 26Y10 (Satellite Communications Ground Station Equipment Repair) course at USASC&FG. The laboratory is a seven day portion of the 26Y10 course dealing with the configuration, programming and troubleshooting of the AN/GSC-24.

The operational test, which was designed to be conducted with a minimal disturbance of normal USASC&FG routines, was run during June of 1982. A class, consisting of a total of 64 students in three sections, was randomly assigned to either control or experimental treatments. The control students practiced in the laboratory using the current equipment-dependent system. The experimental students practiced on the MP/VD system. Both groups, while not in the laboratory, worked on configuration worksheets in the classroom. The test plan was designed to gather three basic types of data on each student--entry, process, and output.

In order to determine the equivalence of the control and experimental groups, entry level measures were obtained on educational level, prior electronics training, general and electronics aptitude test scores, and test scores on prior units of the 26Y10 course. The two groups were found to be equivalent on five of the seven measures. On the basis of correlation analysis, it was determined that the other two scores probably had little or no effect on the final results of the evaluation.

Process measures taken as a part of the test were concerned with effects on student practice (total practice time and trials completed) and system costs. Because of the difference in the number of practice stations available (5 as opposed to 3) the control students were able to complete more trials (3.64 as opposed to 1.94) and obtained more practice time (125.64 minutes as opposed to 85.32) than the MP/VD students. Software production costs for the MP/VD system were found to be \$18,700. The per learning station cost of the MP/VD system was \$7,180. The per learning station cost of the current equipment-dependent system is \$51,000.

Three different output measures were taken during the test--student score on the section of the unit test dealing with programming of the AN/GSC-24, time to complete the appropriate sections of the unit test, and student attitudes. Despite the advantage that the control students had in regard to practice time, there were no statistically significant differences between the control and experimental groups on either unit test score or time on unit test. The experimental students were consistently more negative than the control students, but statistically significant differences were only found on four of ten items on the opinion questionnaire.

On the basis of the evidence developed during the test, it is possible to draw the following general conclusions: (1) EIMTP by means of MP/VD delivery systems is an effective alternative to the current equipment-dependent systems of providing such training. (2) EIMTP by means of MP/VD delivery systems is more efficient in terms of the amount of practice time required. (3) EIMTP by means of MP/VD is less expensive than the equipment-dependent system and therefore is more cost-effective. (4) Students, on this test, prefer the equipment-dependent system.



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1. INTRODUCTION

This is the final report on a project to operationally test and evaluate a microprocessor-controlled videodisc (MP/VD) delivery system as a means of providing Equipment-Independent Maintenance Training Programs (EIMTP) in situations where low equipment density and/or high equipment cost make "hands on" equipment training potentially uneconomical. The project was implemented by the Training Developments Institute (TDI), Fort Monroe, Virginia, in response to the request of the United States Army Signal Center and Fort Gordon (USASC&FG).

Background

This project is an extension of earlier developmental efforts conducted by the Educational Technology Division (ETD) of USASC&FG and TDI. A major mission of ETD is to investigate the application of new technologies to all areas of educational development and military training at USASC&FG. One recent area of concentration has been the use of interactive MP/VD delivery systems as a means of providing practical experience on communications-electronics equipment.

Until recently, two basic methods of providing "practical experience" on communications-electronics equipment have been employed. The first was a practical exercise using actual equipment. This method created problems due to the low density and high cost of some types of equipment and, in many cases, excessive maintenance costs due to the need to "power up and power down" equipment which is designed to be left in a "power up" condition most of the time. The second approach to providing practical training has been the development of "face-plate mock-up," equipment specific simulator systems. The development of such simulators has eliminated some of the problems inherent in the use of actual equipment. However, the relatively high development and production costs and limited flexibility of simulators has restricted their application to situations where cost-effectiveness is easily demonstrated. Progress in electronics and telecommunications technology has led to the recent development of MP/VD delivery systems which appear to offer a highly flexible, relatively low cost alternative to either of the existing approaches to the provision of "hands on" training.

The videodisc is a method of optical storage and laser readout of video signals on a disc. When attached to a video display tube and provided with the proper control device, each disc can store 54,000 still pictures or up to half an hour of motion programming on each side and carries a two channel (stereo) audio sound track. Each picture can be randomly accessed and mixed with motion sequences. Material can be viewed in a variety of modes: freeze frame; frame-by-frame; or slow motion, normal, and fast speeds in both forward and reverse.

In the MP/VD delivery system, a microprocessor provides the control system for the videodisc stored material and provides the basic instructional logic. The microprocessor provides random access memory, full character key-

board, graphics capabilities, floppy disc storage of programs, and the capability to interface with other items of electronic equipment.

Student interaction with the MP/VD system can be provided by keyboard, light pen, or touch panel. Previous studies by TDI and USASC&FG indicate that the best method of student interaction would be by means of touch panel. This method allows the student to simulate the actual equipment by means of visual selection and touching of specific controls in sequence as they are displayed on the screen.

The MP/VD delivery system with touch panel control, as illustrated in Plate 1 below, has the potential to be a versatile and relatively inexpensive system which combines computer assisted instruction with video display. Using the system, the student interacts with the video display provided by the videodisc and controlled by the microprocessor to perform patching on equipment, make switch settings, or perform adjustments of circuits using meters by touching the appropriate spots on the display surface as required by the program. When necessary, the system can provide branching and remedial instruction as needed by the student.



Plate 1. Student Using a Touch Panel to Interact with the MP/VD Delivery System

One area where the potential benefits of the MP/VD system might be applied is in the tri-service MOS 26Y10 course (Satellite Communications Ground Station Equipment Repair) at USASC&FG. This 36 week course provides Army, Navy, and Air Force enlisted personnel with the skills and knowledge needed to

operate, troubleshoot, and repair the digital communications subsystem and satellite communications ground terminals used in military communications systems. This course provides instruction in, and makes use of, a large number of low density, high cost items of equipment which have the potential of testing the MP/VD system as a means of providing EIMTP.

The target for this test and evaluation was a seven day portion of the 26Y10 course dealing with the configuration, programming, and troubleshooting of the AN/GSC-24 Multiplexer. Specifically, the unit of instruction selected for the test was a three day laboratory dealing with the programming of the AN/GSC-24. As illustrated in Plate 2 below, students currently work with the actual equipment in this laboratory. Working from configuration work sheets, the student selects the proper channel and common cards from the multiplexer, makes the necessary pin connections, and inserts the cards in the appropriate machine slots.



Plate 2. Student Removing Channel and Common Cards from the AN/GSC-24 Multiplexer Prior to Programming

Problems are caused by the high cost of the AN/GSC-24 (approximately \$51,000 per multiplexer), the limited number of stations (four) available in the laboratory for the number of students in the course (60 to 65 per class), and excessive wear on the cards, requiring frequent replacement (costing about \$400 per card) and repair of damaged pin connectors.

Purpose

This operational test and evaluation has been established by TDI and USASC&FG in order to:

1. determine the feasibility of using an MP/VD delivery system to provide effective EIMTP and
2. determine the relative cost and effectiveness of such an EIMTP system in comparison to the current equipment-dependent system.

If the MP/VD delivery system can be demonstrated to be an effective means of providing practical experience with electronics equipment, it has the potential of increasing the effectiveness and efficiency of military training in a wide variety of settings.

Evaluation Design

The evaluation plan was designed to retain simplicity and clarity of procedure in implementation, data collection, and evaluation, so that the test might be conducted with a minimum of disturbance of normal routines of the 26Y10 course. A Test Monitor and Data Collector was assigned to the project at Fort Gordon. In addition to monitoring the test, the Data Collector was responsible for gathering entry, process, and output data on students under both the control and experimental treatments, as called for on the Student Data Form and the Student Opinion Form, at Appendix A-1 and A-2. The Evaluator was responsible for verification of the accuracy of the information provided by the Data Collector, for the analysis of the data from the test, and for preparation of the final evaluation report.

Initially, two classes were identified for the test. The first class, referred to as the "control" class, was to work through the target module during November of 1981 and was to be used to collect base line data with which to compare the experimental class. The second, or "experimental," class was to work through the target module during February of 1982. Because of problems discussed in the section of this report dealing with Conduct of the Test, page 9, it was necessary to modify the initial test and evaluation plan to increase the degree of control over extraneous variables. Instead of using separate control and experimental classes, students within a single class were assigned, on a random basis, to either the experimental or control treatments. This process provided better control of outside variables which might have had an effect on the test results and helped to ensure that any differences observed between the two groups of students were only due to differences in treatment.

As illustrated in Figure 1 on page 5, the treatment of both the control and experimental groups was the same, with the exception of the three day laboratory dealing with the programming of the AN/GSC-24. The control students worked in the laboratory, four students at a time, on the actual equipment. The experimental students, four at a time, worked with the MP/VD de-

livery system. Students in both groups, who were not working on programming, remained in the classroom and worked on configuration worksheets. While in the laboratory, each student was to work through three basic configurations. The only variation from normal procedures during the laboratory was that the instructor was required to record the practice time for each student in addition to the number of trial configurations completed.

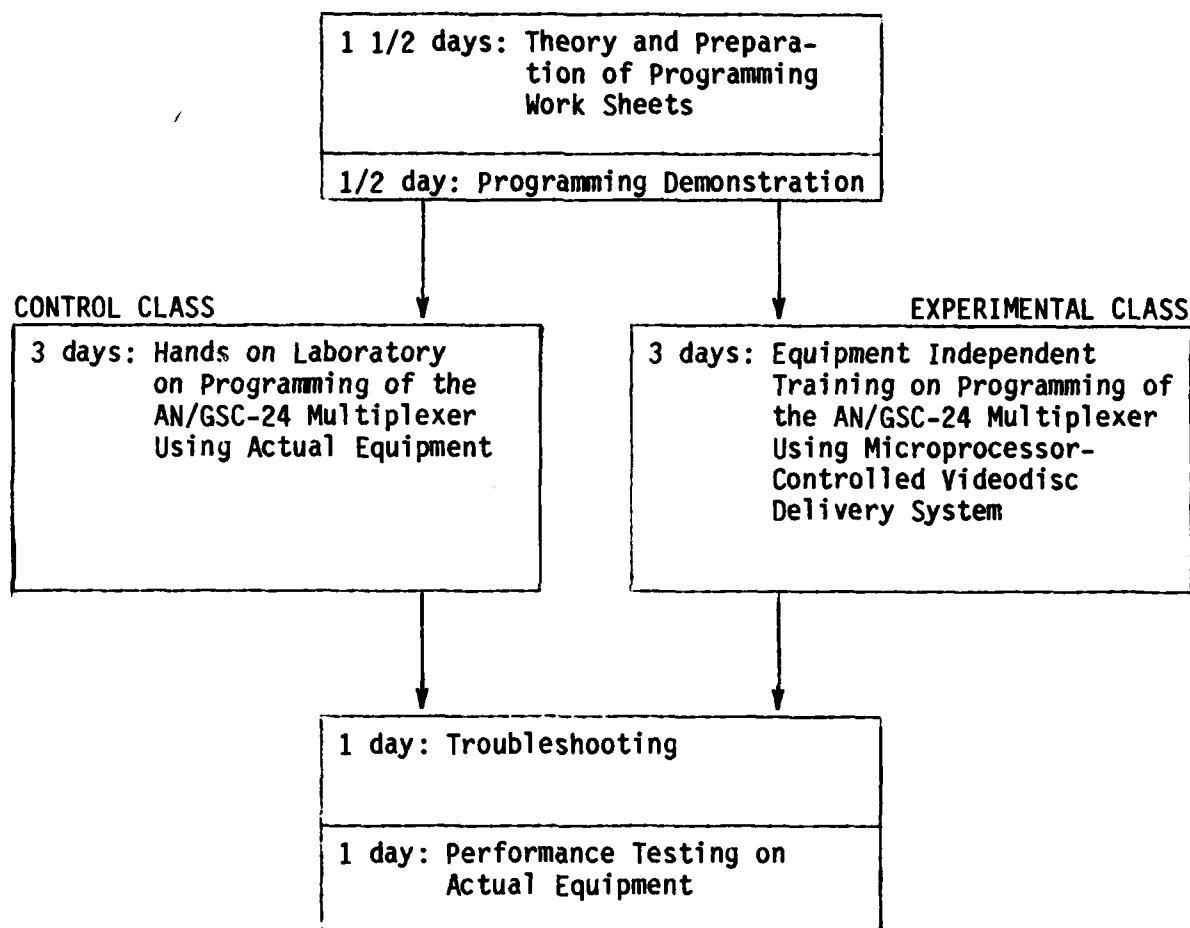


Figure 1: Comparison of Control and Experimental Treatments Within the AN/GSC-24 Unit

The study was designed to gather three basic types of data: entry, process, and output. Each type of data was used to answer specific evaluation questions.

The following entry level data measures were taken (when available) for each student in both the control and experimental groups: Educational Level (in years), General Aptitude Test Score, Electronic Aptitude Test Score, Prior Electronics Training (in weeks), and Scores on Prior Modules of

26Y10 (two tests). This data was used both to verify the equivalency of the two groups by means of analysis of variance techniques and to determine the most effective predictor(s) of student success by means of product-moment correlations. The data was gathered from existing records, when available, and recorded on the individual's Student Record Form. It was necessary to have the students provide some of this information (educational level and prior training) during opinion testing.

The following process measures were taken for individual students in both the control and experimental groups: Practice Configurations Completed and Practice Time. These measure were used to determine if the EIMPT provided any different pattern of practice than did the equipment-dependent system by means of analysis of variance techniques. In addition to student measures, USASC&FG gathered cost data for each element of both the MP/VD and equipment-dependent systems in order to determine the relative costs of the two systems.

The following output measures were taken for each individual student in both the control and experimental groups: Performance Test Score on Programming the AN/GSC-24, Time to Complete Programming Test, and Student Attitudes. The performance test score was taken from Parts II and III of the existing Performance Test AN/GSC-24 Student Answer and Score Sheet, see example at Appendix A-3 and A-4. The output measures were used to determine the relative effectiveness of the EIMPT training by means of the MP/VD system in comparison with the equipment-dependent system currently employed. Analysis of variance techniques were used to determine the significance of any differences between the groups.

Population Description and Treatment

The students in the 26Y10 course consist of Army personnel (both basic students (26Y) and field personnel (F40) who are in for advanced training), personnel from the Air Force and Navy (F39), and foreign nationals. The class used for the test and evaluation consisted of 64 students. Of these 64 students, five were foreign nationals. Because of the difficulties in gathering entry level data on foreign students and because such students were kept together as a group rather than distributed across sections and treatments, data from foreign students were dropped from the analysis, leaving a total of 59 students in the test.

In order to handle the number of students in each class with the limited amount of practice equipment available, each class was divided into three shifts of approximately 20 to 22 students on a random basis. During the AN/GSC-24 unit, students were assigned to either the control or experimental treatments on a random basis. The distribution of student types within each of the treatments is presented in Table 1 on page 7. The application of Chi Square frequency analysis techniques indicates that the distribution of student types between the treatments are close to normal (<.99 level of probability) for the general population.

Table 1. Distribution of Student Types Over Treatments

Student Type	Control	Experimental	TOTAL
Army Basic Personnel	18	16	34
Air Force and Navy Personnel	11	10	21
Army Field Personnel	2	2	4
TOTAL	31	28	59

In order to determine the equivalence of the control and experimental groups, entry level measures were obtained on a number of different measures. Educational level (in years of schooling completed) and prior electronics training (in weeks completed) were obtained from student reports on the Student Opinion Form. General aptitude and electronics aptitude test scores were obtained from USASC&FG records for Army basic personnel. Test scores on the previous units of the 26Y10 course, the Principles and the AN/FCC-98 units, were obtained from the student course records. The mean values obtained for both the control and experimental groups and the number of students upon which the means are based are presented in Table 2 below.

Table 2. Comparison of Mean Entry Level Variables

Entry Measures	Control		Experimental		p
	n	mean	n	mean	
Educational Level (in years)	28	12.54	30	12.27	<.0011*
General Aptitude Score	16	117.56	17	111.41	<.0996
Electronics Aptitude Score	16	118.75	18	114.83	<.4122
Electronics Training (in weeks)	28	50.71	29	52.14	<.2977
Principles Unit Test Score	28	83.39	31	85.13	<.8844
AN/FCC-98 Unit Test Score	28	97.00	30	97.33	<.0396*

*statistically significant

Analysis of variance techniques were employed in order to determine if the obtained differences between the control and experimental groups were statistically significant. The probability of statistical difference obtained from the t test for each of the entry level variables is presented in the right hand column of Table 2. A probability level of .05, or less, was set as

the level at which the differences between the groups would be considered statistically greater than the differences within the groups. On this basis, the groups were found to be statistically different on two factors--Educational Level and the AN/FCC-98 Unit Test Score. These differences, although statistically significant, were relatively small--the control group being favored by .27 of a year on Educational Level and the experimental group being favored by .33 of a point on the AN/FCC-98 Unit Test.

In order to determine if differences in entry level variables affected the student's performance, Pearson product-moment procedures were employed to determine the degree and significance of any correlation between entry level variables and either the AN/GSC-24 programming test score or the time required to complete the programming section of the unit test. The correlation coefficients and probabilities obtained are presented in Table 3 below.

Table 3. Correlation of Entry Level and Output Variables

Entry Variables	Post-Test Score		Time on Post-Test	
	coefficient	p	coefficient	p
Educational Level (in years)	.13	<.3277	-.06	<.6551
General Aptitude Score	.27	<.1311	-.27	<.1241
Electronics Aptitude Score	.37	<.0329*	-.30	<.0903
Electronics Training (in weeks)	-.08	<.5471	-.15	<.2763
Principles Unit Test Score	.06	<.6376	.00	<.9938
AN/FCC-98 Unit Test Score	.25	<.0556	-.06	<.6348

*statistically significant

On almost all of the entry level variables, there was a slightly positive correlation with the Post-Test Score (the higher the entry value, the higher the test score) and a slightly negative correlation with Time on Post-Test (the higher the entry value, the less time required to complete the test). This trend was reversed on only two of the 12 correlations. The probability that the correlation was not zero was statistically significant for only the Electronics Aptitude Score with the Post-Test Score. Since there was no significant difference between the control and experimental groups on this variable, it should have had no effect on the output measures. Those entry variables on which the two groups were statistically different were relatively low predictors and, since each favored a different group, should have cancelled each other out on output measures.

2. DISCUSSION

Conduct of the Test

The original test and evaluation plan called for the control class to go through the AN/GSC-24 module in November of 1981 and for the experimental class to go through the module in February of 1982. Data was gathered on the initial control class; however, the MP/VD software was not ready at the targeted date for the experimental class. The first classroom tryout of the experimental treatment was in May of 1982. In the time period between November of 1981 and May of 1982, course enrollments increased from approximately 30-40 students to approximately 60-65 with no increase in Program of Instruction (POI) time. This, in effect, reduced the amount of time which individual students could spend in the laboratory and created a significant difference in treatment between the original control class and the experimental class, invalidating the control data which had previously been gathered. This is the primary reason that the evaluation design was modified to a split section design as described previously on page 4.

For a number of reasons, no useful data was gathered during the May experimental session of the AN/GSC-24 unit. This was the first use of the touch panel in a student environment (previously tested MP/VD systems had made use of a light pen for student interaction) and a number of technical problems developed which needed to be solved. A power surge within the classroom building caused the air conditioning to go down and caused the touch panels to go out of alignment. The location of the MP/VD units within the AN/GSC-24 laboratory caused confusion and problems due to powering up and down of the multiplexer. One of the touch panels burned out, reducing the number of available MP/VD stations to a single unit. The computer software needed to be modified to make the program more "user friendly." Operational procedures within the course needed to be modified and additional MP/VD units secured in order to accommodate the increased number of students. As a result, the May class was treated as a "de-bugging" operation. The final test and evaluation was conducted when the subsequent class went through the AN/GSC-24 unit in June of 1982.

During the test, there was one slight deviation in the testing routine between the control and experimental students. On Part II of the examination, control students were required to select the proper cards from an assortment of cards. This caused a high level of fear on the part of the experimental students because they had not been confronted with this task in the MP/VD program. As a result, the experimental students were provided with the appropriate cards for the task during testing.

Process Variables

The POI called for students to work through three trial configurations during the programming laboratory. In order to see if the application of the MP/VD delivery system would have any effect on practice patterns, a record was kept of the number of trial configurations completed and of the time required

for completion by each student under both the control and experimental treatments. Analysis of variance was employed to determine any statistical differences between the two treatments. A summary of the results of this comparison is presented in Table 4 below.

Table 4. Comparison of Mean Process Variables

Process Measures	Control		Experimental		p
	n	Mean	n	Mean	
Trial Configurations	28	3.64	31	1.94	<.0001*
Trial Time (in minutes)	28	125.64	31	85.32	<.0003*

*statistically significant

The differences between the control and experimental groups in regard to Trial Time and Trial Configurations completed are both readily apparent and statistically significant. The control students completed approximately three and a half configurations (3.64) while the experimental students completed slightly less than two (1.94) configurations. This was primarily due to the fact that, although both the control and experimental students were allowed an equal number of laboratory days, they did not have an equal number of training stations which reduced the relative amount of time that any one experimental student could spend working through trial configurations. The control students had four practice stations to work with in the laboratory (plus an additional demonstrator in the classroom) while an equal number of experimental students were working with only three MP/VD stations. MP/VD students also required longer (an average of 49.13 minutes) to work through a configuration than the control students (34.52 minutes). This higher average time was partially due to the branching and remedial nature of the MP/VD program used by experimental students, but was primarily due to the lower number of trials completed. Average time per configuration would drop as students worked through more trials.

The lower number of practice stations created a major disadvantage for the experimental students. If both common sense and educational theory regarding the effects of practice on student performance hold true, the control students should have performed significantly better than the experimental students on the unit examination. This, as will be seen in the section dealing with Findings, was not the case.

Cost Variables

Currently, with the classroom demonstrator and the four laboratory AN/GSC-24 units, there are five stations available for equipment-dependent training. With an average of 20 students per section, this allows 3.0 hours per student for hands-on training. The 26Y10 course personnel have recommended that the number of equipment stations be increased to a total of eight in

order to increase average per student hands-on training to 4.9 hours. At a per unit cost of \$51,000, this represents an additional equipment cost of \$153,000, exclusive of the cost of installation.

The costs of the MP/VD delivery system includes the cost of the delivery system hardware, software development and pre-planning, software production, and the reproduction of software. These costs are summarized in Table 5 below.

Table 5. Summary of MP/VD Delivery System Costs

Cost Item	\$ Cost per Item
DELIVERY SYSTEM HARDWARE COSTS	
Apple II Plus Microprocessor with 48k Memory	1,530.00
Disk II Drive with Controller (Apple Computer Co.)	675.00
Clock/Calendar Card (Apple Computer Co.)	225.00
Videodisc Interface, VAI-2 (Coloney Productions).	500.00
13" Video Monitor (Zenith).	450.00
Videodisc Player, Model DVA 7820-2 (DiscoVision).	2,000.00
Touch Panel, Model 1004 (Sierracin Corporation)	1,000.00
Storage Case.	800.00
TOTAL HARDWARE COSTS PER LEARNING STATION	7,180.00
SOFTWARE PRODUCTION COSTS	
Software Development and Pre-planning	6,000.00
Software Prototype Production	
Videotape Production.	4,800.00
Microprocessor Control Program.	4,500.00
Reproduction of Software	
Videodisc Mastering	3,200.00
20 copies of Videodisc at \$10.00 per copy	200.00
TOTAL SOFTWARE COST	18,700.00

Hardware and software production costs cited in Table 5 are from figures provided by USASC&FG personnel. The software development and pre-planning costs are based on the costs of one GS11, support staff, supplies, etc., for a 4-6 week period to develop the initial instructional design. Videotape

production costs are based on a production staff of six working for two weeks at \$10.00 per man hour (6 people X 40 hours per week X 2 weeks X \$10.00 = \$4,800.00). The microprocessor control program costs are based on an estimate of 90 working days for a single programmer. This is considerably longer than the normal 30 days required for a program because three different programs were required--one for each of the three different configurations. The total cost of software production (\$18,700) compares very favorably with the cost of commercial interactive videodisc production (estimated at from \$100,000 to \$250,00).

The cost per learning station for the system hardware (\$7,180.00) compares favorably with the cost per station of actual equipment (\$51,000.00). This is particularly true when it is taken into consideration that the same learning station, by means of different software, can be used in place of several different items of actual equipment.

Electronics equipment in the training environment gets 150% to 300% more usage than in a field setting. A major problem with the equipment-dependent system is caused by constant powering up and powering down of equipment which is designed to be in a constant power up condition. Also, faulty programming causes excessive damage to control cards in the AN/GSC-24. During the period from April to October of 1981, 12 cards were sufficiently damaged to require that they be shipped to Tobyhanna Army Depot in Pennsylvania for repair or replacement at a cost of over \$400 each and a turn-around-time of approximately four months. The necessity of stocking a supply of extra cards adds several thousand dollars to the cost of the equipment-dependent training.

According to USASC&FG personnel, there have been no operational or maintenance costs on the MP/VD systems. This is true if the problems encountered with the touch panels are considered as "de-bugging" problems rather than normal operation. The lack of maintenance costs can be attributed to the limited amount of use being made of the MP/VD stations during experimental use.

Findings

Several different measures of the output from this evaluation were taken. These measures can be grouped into two major categories--measures of effectiveness and measures of acceptance--and will be discussed in detail under each of these headings.

Measures of Effectiveness

Effectiveness measures are those measures which relate to the overall levels of skill developed by students as a result of the instruction provided. Measures which relate to effectiveness that were obtained during the evaluation include Post-Test Score on those portions of the end-of-unit test which relate to programming of the AN/GSC-24 and Time on Post-Test (in minutes) for the appropriate sections.

The mean Post-Test Score and Time on Post-Test obtained for both the control and experimental students are presented in Table 6 on page 13. As would be expected as a result of the significantly larger number of trials completed and practice time for the control students, the results favor the control group--both in terms of raw score on the examination and in terms of time required to complete the examination. When, however, analysis of variance techniques were applied, no statistical difference was found between the two groups. This was due to the wide variance of scores (a range from 10 to 35 points and from 8 to 35 points on Post-Test Score, from 11 to 30 minutes and from 15 to 35 minutes on Time on Post-Test) within both groups as opposed to the variance between the groups.

Table 6. Comparison of Mean Output Variables

Output Measures	Control		Experimental		p
	n	Mean	n	Mean	
Post-Test Score	28	31.21	31	27.84	<.5296
Time on Post-Test (in minutes)	28	19.27	31	29.23	<.8957

Measures of Student Acceptance

In order to determine student reactions to the MP/VD delivery system, an opinion questionnaire was presented to both control and experimental students following completion of the unit. Students were asked to indicate their degree of agreement or disagreement with ten different statements concerning their satisfaction with the instruction they received by circling the number (1 = strongly agree through 5 = strongly disagree) which most closely reflected their feelings. A number of the statements were paired together (different wording of the same factor) in order to establish the consistency of student responses. The mean responses for both groups of students are presented in Table 7 on the following page. Analysis of variance techniques were applied to determine if any of the differences between the groups were large enough to be considered statistically significant. The probabilities of difference are presented in the right-hand column of Table 7.

The control students indicated a stronger degree of agreement with all but two of the statements--the eighth statement dealing with the need for additional "hands on" practice and the ninth statement dealing with the need for instructor assistance to work through the laboratory. However, the differences were statistically significant on only four of the ten statements. The more negative feelings of the experimental students are born out by the fact that 23 of them, as compared to 9 of the control students, were moved to provide written comments in the spaces provided on the form. The various paired statements and a sampling of the student comments will be discussed in detail in the following paragraphs.

Table 7. Comparison of Mean Agreement on Attitudinal Measures

Statement	Control	Experimental	p
1. I am confident that I have developed a high level of ability in programming the AN/GSC-24.	2.11	3.26	<.0570
2. The classroom demonstration dealing with programming of the AN/GSC-24 was clear and helpful.	2.59	2.81	<.0032*
3. The laboratory instruction and practice in programming of the AN/GSC-24 was clear and helpful.	2.04	3.45	<.0001*
4. The instructor was very helpful to me during the laboratory portion of unit.	1.89	2.20	<.0592
5. The laboratory practice in programming the AN/GSC-24 was effective and well organized.	2.25	3.29	<.0499*
6. I feel that the training I received in programming the AN/GSC-24 was as effective as it could be.	2.79	3.68	<.0900
7. The arrangement of the laboratory space and equipment was efficient and easy to use.	2.15	2.36	<.0034*
8. I would feel more confident in my ability if I had had more "hands on" practice with the equipment.	1.82	1.35	<.6987
9. I feel that I could have worked through the programming laboratory without much direct instructor assistance.	3.25	2.84	<.5280
10. I see no reason why there should be any changes in the way training is provided in programming the AN/GSC-24.	3.12	3.97	<.6401

*statistically significant

Two of the items, numbers one and eight, dealt with the students' degree of confidence in their ability to program the AN/GSC-24. The control group indicated a higher level of confidence and the experimental group indicated that they would have felt more confident if they had more "hands on" training but neither of these differences were statistically different. Both

control and experimental groups, in fact, indicated a strong agreement with the need for more hands on training.

The POI called for a group demonstration of programming prior to the laboratory. Item two examined the effectiveness of this demonstration. There was a significant difference in the opinions of the two groups--the control group being more positive. Examination of student comments indicated that this demonstration was not provided for one of the three sections.

Items three and five dealt with the clarity, organization, and effectiveness of the laboratory instruction. On both of these items, the experimental students were significantly more negative than the control students. In their comments, the students made a number of references to the lack of "hands on" experience with the actual equipment. They did not see the MP/VD system as an equivalent experience and indicated a high degree of anxiety in regard to the performance examination.

Items four and nine dealt with the effectiveness of the instructors. Items six and ten dealt with the students' general level of satisfaction with the unit of instruction. Although the experimental students were more negative than the control students, there were no statistically significant differences between the groups on any of these items.

The majority of the comments from the experimental students indicated the desirability of combining the MP/VD instruction with the "hands on" instruction rather than using the MP/VD in a totally independent mode. The most common comment from both groups of students concerned the lack of time in the laboratory to work through enough configurations in order to feel comfortable with the equipment.

3. SUMMARY AND CONCLUSIONS

In reviewing the results of this test, it is important to keep in mind that it was an operational test that occurred in an actual work environment rather than a laboratory setting. All efforts were made to maintain the normal operational procedures of USASC&FG and the MOS 26Y10 course.

The lack of a sufficient number of MP/VD practice stations created a real problem in providing the experimental students with an equivalent amount of practice time per student on the equipment when compared to the control students. Also, the distinction between the statistical significance and the practical importance of any reported differences must be kept clear when interpreting the results reported in this evaluation. With the small number of subjects examined in the test, it is relatively difficult to find statistical differences between groups.

The evidence presented in this report is consistent with other evaluations of MP/VD delivery systems conducted by TDI and USASC&FG. It is possible to draw the following general conclusions from the test and evaluation:

1. EIMTP by means of MP/VD delivery systems is an effective alternative to the current equipment-dependent system of providing such training.
2. EIMTP by means of MP/VD delivery systems is more efficient in terms of the amount of practice time required than the current equipment-dependent system.
3. EIMTP by means of MP/VD delivery systems is less expensive than the equipment-dependent system and therefore is a more cost-effective alternative.
4. In this test, students prefer the equipment-dependent mode of instruction over the EIMTP alternative.

4. RECOMMENDATIONS

It would be wise to conduct other studies of the effectiveness of MP/VD delivery systems to perform a variety of instructional tasks before any firm or final conclusions are reached. Also, because the same stations can be used to simulate a wide variety of equipment with just a change of software, such expansion would help to realize the full cost saving potential of MP/VD delivery systems. In such studies, care should be taken to ensure sufficient instructional stations to handle the number of subjects.

This study demonstrates that EIMTP by means of MP/VD is effective. The experimental students were able to perform statistically as well as the control students with only approximately half the practice time. Its best use, however, might not be as an independent mode of instruction. The high anxiety of the experimental students indicates that the best possible use of the MP/VD system might be in combination with "hands on" the actual equipment. In this manner, the MP/VD system could be used to hold down the cost of equipment needed to handle the increased enrollment in the 26Y10 course. Another effective use of the EIMTP would be in field settings where extra items of equipment are not available for review of training.

STUDENT DATA FORM

FOR USE OF
EVALUATOR
ONLY

BASE LINE DATA:

1. Student's Name: _____
2. Treatment (check one): ☐ control
☐ experimental
3. Student ID Number: _____
4. Student Type (check one): ☐ 26Y (Army)
☐ F39 (Air Force/Navy)
☐ F40 (Army Field Personnel)
☐ foreign national
5. Aptitude Test Scores: GT _____
EL _____
6. Score on Principles Module of 26Y10: _____
7. Score on AN/FCC-98 Module of 26Y10: _____
8. Educational Level (on back side of this form):
9. Prior Training in Electronics (on back side of this form):

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PROCESS DATA:

10. Number of configurations completed by student during laboratory periods: _____
11. Time spent by student working through configurations during the laboratory: _____

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OUTPUT DATA:

12. Score of Performance Test AN/GSC-24, Parts II & III: _____
13. Time to Complete Parts II & III of Performance Test: _____
14. Attitudinal Responses (on back side of this form):

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STUDENT OPINION FORM

React to each of the following statements by circling the number in the right-hand margin which most closely reflects the degree to which you either agree or disagree with the statement. If you wish to elaborate or comment on your responses, make use of the space provided.

STRONGLY DISAGREE
DISAGREE
UNDECIDED
AGREE
STRONGLY AGREE

- | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. I am confident that I have developed a high level of ability in programming the AN/GSC-24.
<u>comment:</u> _____ | | | | | |
| 2. The classroom demonstration dealing with programming of the AN/GSC-24 was clear and helpful.
<u>comment:</u> _____ | | | | | |
| 3. The laboratory instruction and practice in programming of the AN/GSC-24 was clear and helpful.
<u>comment:</u> _____ | | | | | |
| 4. The instructor was very helpful to me during the laboratory portion of this unit.
<u>comment:</u> _____ | | | | | |
| 5. The laboratory practice in programming the AN/GSC-24 was effective and well organized.
<u>comment:</u> _____ | | | | | |
| 6. I feel that the training I received in programming the AN/GSC-24 was as effective as it could be.
<u>comment:</u> _____ | | | | | |
| 7. The arrangement of the laboratory space and equipment was efficient and easy to use.
<u>comment:</u> _____ | | | | | |
| 8. I would feel more confident in my ability if I had had more "hands on" practice with the equipment.
<u>comment:</u> _____ | | | | | |
| 9. I feel that I could have worked through the programming laboratory without much direct instructor assistance.
<u>comment:</u> _____ | | | | | |
| 10. I see no reason why there should be any changes in the way training is provided in the programming of the AN/GSC-24.
<u>comment:</u> _____ | | | | | |
| 11. What is the highest grade level (formal education) you've completed? _____ | | | | | |
| 12. Estimate the number of weeks of prior training in electronics that you have had (including the 26Y10 course). _____ | | | | | |

PERFORMANCE TEST AN/GSC-24
STUDENT ANSWER AND SCORE SHEET

Final Score _____(100)

NAME _____

DATE _____

INST _____

LAB POS# _____

GROUP _____

INSTRUCTION: This is a four(4) part examination to test your knowledge to (1) prepare configuration, worksheets (2), program channel and common cards(3), Inserting proper cards into the AN/GSC-24 multiplexer (4) performing fault isolating and operating the AN/GSC-24 multiplexer.

PART I. Preparation of the AN/GSC-24 multiplexer configuration worksheets. Time 1 hour.

1. Complete four(4) configuration worksheets using the following information:

NOTE: Obtain configuration worksheets from test administrator.

a. Port Rate ----- 50 kbps

b. Input/Output Data Rates: (Multiplexer)

(1) CH# 1 ----- 50 kbps

(2) CH# 2 ----- 768 kbps

(3) CH# 3 ----- 100 kbps

(4) CH# 4 ----- VOICE

c. Error Rate Thrushold ----- 10³

d. Data ϕ (phase) ----- Normal

e. Input/Output INFC ----- 75B

f. Timing ----- External

NOTE: Turn-in configuration worksheet to the test administrator as soon as you complete all four(4) sheets.

2. Score for Part I ----- (40)

102-F39/S11-LPW-SACS
102-F40/S11-LP1-SACS
102-26Y10/S11-LP1-SACS

PART II. Programming channel and common cards. (Time 30 minutes)

NOTE: The test administrator will provide a separate area (lab) for card programming. (Technical manual & note may be used).

1. Using your prepared configuration worksheets PROGRAM the following channel and common cards:

- a. 1 each ----- RCB Cards (1)
- b. 1 each ----- SB Cards (10)
- c. 1 each ----- RT Cards (5)
- d. 2 each ----- OEG Cards (1)
- e. 2 each ----- SEQ Cards (10)
- 1 each ----- Display card (1)
- 1 each ----- Fs Card (1)
- 1 each ----- ERD Card (1)

NOTE: Have each card checked by the test administrator as soon as you have completed programming each card.

2. Score for Part II ----- (30)

NOTE: Training material will be used to complete Parts III and IV of this test.

PART III: Inserting channel cards and common card into the AN/GSC-24 multiplexer, time: 5 minutes.

1. Using your configuration worksheets No 1-4 insert channel cards and common cards into their proper slots in the AN/GSC-24 multiplexer set.
2. Score for Part III ----- (5)

PART IV: Fault isolation and AN/GSC-24 multiplexer operation time: 10 minutes.

1. Using front panel controls and indicators isolate multiplexer faults(s).
 - a. Faulty units
 - (1) Cards _____
 - (2) Others _____
 - b. Repair AN/GSC-24 multiplexer by card replacement.
 - c. Self test multiplexer.
2. Score for Part IV. ----- (25)

END
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102-F39/S11-LP1-SACS
102-F40/S11-LP1-SACS
102-26Y10/S11-LP1-SACS

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